A Thin-Section Analysis of Pre-Cambrian Metamorphic Rocks In the Vicinty of Breckenridge, Colorado

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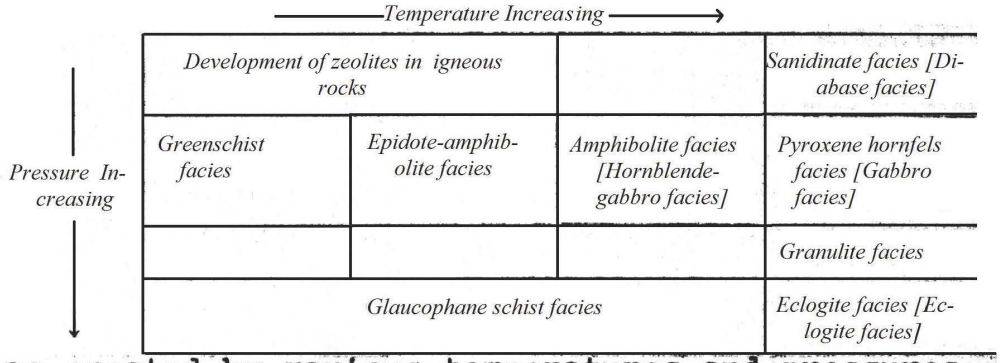
The purpose of this exercise is to study the relationships between metamorphic minerals and rocks and thereby determine the pressure, temperature and mineralogic conditions under which they were formed. In this study, fifty thin-sections, numbered M-670 to M-718, have been examined as to their fabric and mineral content in order to classify them into the existing metamorphic facies as established by P. Eskola, and Turner and Verhoogen.

The thin-sections were prepared from samples collected by Prof. E. G. Ehlers during field studies in the vicinity of Breckenridge, Colorado. Since the rocks were collected at random, at the bottom of a canyon (Middle Fork Swan River, Keystone Quadrangle), no data is available for the creation of a geologic facies map of the area. It also is not possible to determine, from the thin-sections, whether the collected samples, or the slides prepared from them, accurately represent the percentages of rock types located in this region. It can be assumed that the samples are indigenous to the area and can be used to establish some of the metamorphic history of the region.

All of the thin-sections in this collection have been found to be the result of regional metamorphism. This conclusion is based on the mineral assemblages and fabric present in the samples. Regional metamorphism can be developed in areas amounting to thousands of

square miles. This type of metamorphism is common to folded mountainous regions and in Pre-Cambrian strata, both of which are present in the Breckenridge area. The full range of temperatures and pressures necessary for metamorphic processes are created during regional metamorphism allowing for the developement of a wide range of textures and mineral assembleges. This chart by Eskola shows the relationship of metamorphic facies



as created by various temperatures and pressures. The amphibolite facies is the only facies represented in this collection.

The amphibolite facies is a moderate temperature and pressure facies. This group is divided into three subfacies by mineralogic content. These are, in order of decreasing temperature, the sillimanite-almandine subfacies the kyanite-almandine-muscovite subfacies, and the staurolite-almandine subfacies (Turner and Verhoogen,1960). These divisions have been based on the first occurrence of the minerals staurolite, kyanite and sillimanite corresponding to the temperatures and pressures needed for their formation. It is not necessary that these

particular minerals be present in the rock since the mineral assemblage of the metamorphic rock is based, in part, on its pre-metamorphic chemical composition.

Rocks whose original composition was pelitic will form metapelites in the sillimanite-almandine subfacies of the following composition; garnet+sillimanite+biotite+potassium feldspar+quartz± plagioclase (Dobretsov, Khlestov, Sobolev 1972). The parameters which define this group are easily recognizable in many of the slides in this collection. The following is a collective description of the minerals and textures present of those sillimanite-almandine rocks.

A granoblastic fabric is seen in these rocks. Although the percentage of minerals and textures vary somewhat from slide to slide, schistose foliation is defined by the orientation of sillimanite, biotite and quartz grains.

Quartz is common to all samples, ranging from five to fifty percent. The shape of these grains is xenoblastic. Inclusions include sillimanite, biotite and zircon. Grain boundaries between quartz grains are irregular to slightly sutured. Fractures and uneven extinction patterns are also visible and optical orientation is random. In areas where the schistosity is well developed, quartz grains may be elongate in the direction of the foliation.

Biotite crystals are pleochroic in light brown to brown. Opaque minerals in the rock appear to be limited to an association with biotite. Biotite, when found together with sillimanite, shows intergrowths. Under uncrossed nicols they illustrate the degree of foliation of the rock. These biotites, for the most part, are unaltered, except for the presence of pleochroic halos. The biotite grains in areas of the rock showing little to no foliation, no sillimanite, but dominated by quartz and feldspar grains, tend to be altered to penninite. With uncrossed nicols the altered biotite has a greenish color. Under crossed nicols this alteration shows anomalous blue interference colors.

The sillimanite occurs in two habits in these rocks. When associated with biotite, and as inclusions in quartz, distinct idioblastic grains have developed. The other common modification is that of fibrolite. The fibrolite tends to form in lenticular pods whose length parallel the foliation. Fibers of sillimanite inside these pods are not arranged in the direction of foliation. Spry (1969) writes that since these areas of fibrolite occur with and near undeformed biotite and sillimanite, their growth is the result of "seeded nucleation", indicating a high concentration of sillimanite.

Microcline represents the potassium feldspar.

These grains may show tartan twinning and perthite textures, although not all of the grains are twinned. Most samples contain feldspar with some degree of alteration to sericite; the intensity and amount of alteration is variable. The areas of greatest sericite alteration are also the areas where biotite is largely altered to penninite.

The almandine garnet crystals range from xenoblastic porphyroblasts, many of which have been shattered and broken, to idioblastic crystals. In a few crystals, green muscovite can be found in some of the fractures. Poikiloblasts of quartz, when present, are usually located at the center of the grains and do not show any preferred orientation. Biotite and sillimanite are bent around the garnets and a jumbled array of quartz, microcline and biotite is located in the pressure shadows along either side of the crystals, parallel to the foliation. These conditions indicate that the garnets are pre-tectonic in origin.

No examples of the kyanite-almandine-muscovite subfacies are present in this collection but there are examples of metamorphosed basic rocks of the staurolite-almandine subfacies. The mineral assemblege of this group has hornblende + plagioclase +epidote $\pm$ quartz $\pm$ diopside $\pm$ biotite. These rocks have nematoblastic texture which appears as the preferred orientation of

the hornblende grains. This schistosity usually is best seen microscopically. A granoblastic fabric is seen macroscopically.

Hornblende is a major member of these rocks. The ploechroism of the grains is from yellow-green to blue-green. The grains tend to have well developed amphibole cleavage and are hypidioblastic in shape. Many of the grains have biotite or chlorite alterations; however, no reactions rims are present in this collection. Inclusions of plagioclase, quartz, sphene and apatie are common.

The composition of the plagioclase, as determined by albite twin extinction angles, falls in the oligoclase to andesine range (An_{25}-An_{40}). Although twinning is present in many of these grains, they are rarely of suitable quality to determine exact compositions. Sericite alteration affects most of the plagioclase crystals in these amphibolites. Hornblende, quartz, sphene, apatite and epidote are found as inclusions in the feldspar grains.

The percentage of quartz present in these rocks varies greatly. This is due to the variable chemical composition of the unmetamorphosed parent rock. Amphibolites formed from metamorphosed basic rocks tend to be deficient in quartz. Where quartz is more plentiful, the original rock may have been a tuff (Turner, Williams, Gilbert 1954). The grains of quartz have minor fracturing,

uneven grain contacts and wavy extinction. Inclusions of hornblende, sphene and apatite are common.

Epidote, sphene, and apatite are not major members of the rocks but occur in all of the samples. Epidote occurs as individual grains showing faint green pleochroism. Sphene forms either individual crystals or clusters of grains. Although high in the crystalloblastic series, the sphene in these samples is usually xenoblastic grains without well developed cleavage. Opaque minerals are present as inclusions in both epidote and sphene. Apatite is an accessory mineral that is usually idioblastic in shape.

Rocks with the mineral assemblage of quartz, feldspar, biotite, and minor epidote and muscovite belong to the high-grade foliated rocks termed quartzo-feldspathic schists. (These rocks are named granitic gneisses in the section of thin-section descriptions.) This mineralogy fits the requirements of the staurolite-almandine subfacies (Turner 1949). These rocks are derived from arenaceous sediments and siliceous igneous rocks. The fabric of these rocks is granoblastic with biotite oriented parallel to the foliation and defining the schistosity.

Quartz is the dominate mineral in these rocks. The xenoblastic grains, in some cases, are elongate in the direction of foliation. Fracturing is usually present,

grain contacts are uneven to embayed and the grains have wavy extinction patterns. Biotite, epidote and apatite crystals are common inclusions.

The feldspar group is represented by both potassium and soda-rich feldspars. Tartan twinning and perthite texture are present in the potassium feldspar grains while the plagioclase has faint albite twinning. Extinction angles on these twins indicate that the plagioclase is oligoclase. Sericite alteration occurs in these rocks. Quartz, biotite, epidote and apatite are found as inclusions.

The biotite grains are pleochroic in yellow-brown to dark brown and have both penninite and chlorite alteration. Groups of biotite crystals are rare in these samples. Opaque minerals and quartz are the most common inclusions.

Epidote, having lime green pleochroism, is a minor member of this subfacies. The crystals usually have a granular appearance or occur along fractures.

The epidote-rich rocks can also be classified into the staurolite-almandine subfacies. The mineral assemblage of epidote (with clinozoisite), hornblende, diopside, plagioclase and quartz is formed by the regional metamorphism of calcsilicate rocks and marbles. If no plagioclase is present the rocks originated from basic igneous rocks. The minerals in these rocks do

not show preferred orientation. In fact the grain boudaries are very poorly developed. This gives the rock a granoblastic fabric. Many of the slides which have two distinct mineralogical sections are made of the hornblende-rich amphibolite and the epidote-rich amphibolite. The boundary between these sections is usually very distinct.

The epidote crystals have either lime-green pleochroism and high interference colors, or are non-pleochroic with the anomalous interference colors of clinozoisite. The size and shape of epidote crystals varies greatly from slide to slide. Coarse, idioblastic grains appear in the epidotites but most commonly, xenoblastic grains with very indistinct boundaries are intergrown with hornblende and diopside.

The hornblende grains intergrown with the epidote also have very poorly defined grain boundaries. These grains are pleochroic in blue-green to green. Non-pleochroic hornblende is also present in these rocks and may be tremolite. In some slides diopside can be seen altered to hornblende. Included in these epidote, hornblende and diospide intergrowths are sphene, quartz and plagioclase.

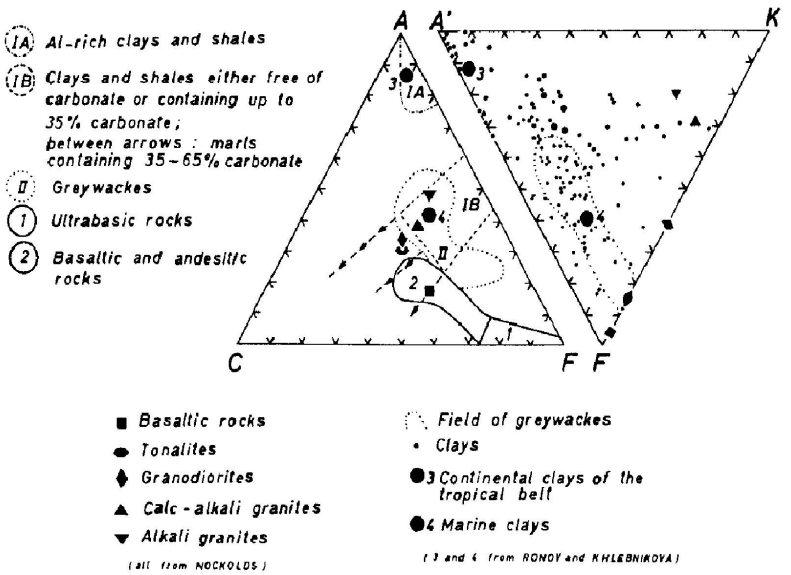
The quartz crystals in these samples have undulose extinctions and embayed contacts. Sphene, apatite and epidote are found as inclusions. Quartz is not present

in all of the rocks of the subfacies.

The plagioclase grains in the epidote-rich rocks have faint albite twinning showingthrough sericite alteration. As with the quartz, plagioclase is not always present in each of these rocks of this subfacies

Three of the slides in this collection, M-678, M-717 and M-718, cannot be categorized as being formed by regional metamorphism. M-678 and M-718 are coarse-grained feldspathic-quartzites. M-717 is a coarse-grained, wholly feldspathic rock, possibly from a pegmatite. Not enough information can be gathered from these samples to accurately determine their origins.

Using the mineral assemblages and grain fabrics to classify the rocks of this collection, their history can be described as follows. The Pre-Cambrian rocks near Breckenridge, Colorado have undergone regional metamorphism at moderate temperatures and pressures. The pre-tectonic strata included basic igneous rocks, pelitic and arenaceous sediments and calcsilicate rocks. These rocks, of different compositions, subjected to the same metamorphic processes, produced amphibolites of varying texture and composition.



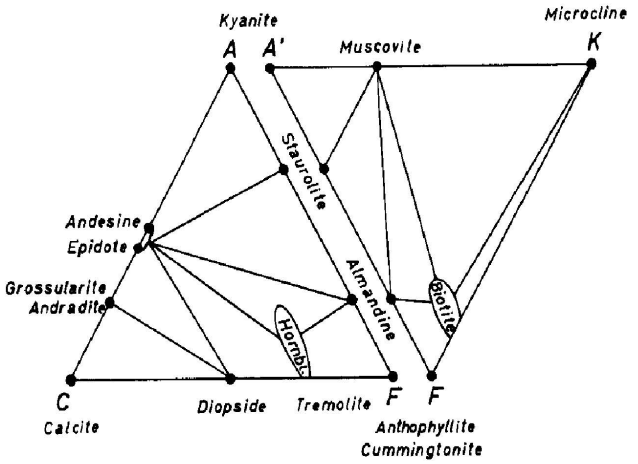
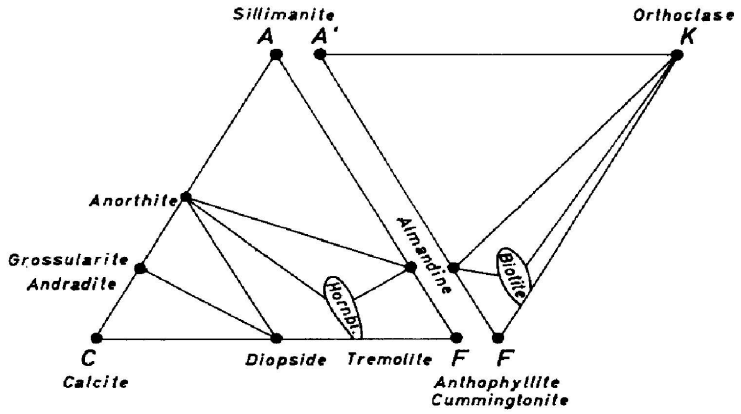


FIG. 27 (B 2.1) Staurolite-almandine subfacies of the almandine-amphibolite facies.



30 (B 2.3) Sillimanite-almandine-orthoclase subfacies of the almandine-amphibolite facies. Epidote + plagioclase are no longer compatible here.

from Winkler, "Petrogenesis of Metamorphic Rocks"

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The following abbreviations are used in the slide descriptions:

biot. - biotite

epid. - epidote

feld. - feldspar

gar. - garnet

hornb. - hornblende

plag. - plagioclase

qtz. - quartz

sil. - sillimanite

NUMBER M-670

NAME qtz-feld-bio-sil-gar-schist

FACIES Amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35	.80 mm	3.50 mm / .03 mm	xenoblas	Sillimanite biot zircon			random fracturing	Contacts even to embayed
Microcline	25/30	.90 mm	6.20 mm / .01 mm	xenoblas	biotite quartz	sericite	tartan	minor fracturing	perthite
Biotite	20/25	.40 mm	1.90 mm / .02 mm	hypidio blastic	zircon quartz sillimanite	pleo. halos penninite			
Sillimanite	15	.02 mm	.50 mm / .01 mm	idioblas fibrolite				longer crystals fractured	
Almandine Garnet	5	4.40 mm	4.40 mm	fract.	muscovite in fract.			highly fractured	pre-tect.
Zircon	<1	.03 mm	.05 mm / .01 mm	Xeno blastic					access.

COMMENTS:

M-670

Sample M-670 is a quartz-microcline-biotite-sillimanite schist. The schistosity is defined by bands of sillimanite and biotite arranged parallel to the foliation; however, single layers are not continuous across the slide. The foliation is not linear, with the bands of sillimanite and biotite flowing around coarse grains of quartz, microcline and porphyroblasts of garnet.

Sillimanite occurr in lenticular pods of fibrolite and as individual idioblastic grains. Most grains in the sample are cut parallel to length. Grains cut perpendicular to the c-axis are not as common but do show a great range in size. Sillimanite is found intergrown with biotite and heavily included in quartz. Crystals of sillimanite tend to be found in groups as isolated grains are rare.

Biotite crystals are pleochroic in light brown to brown. Inclusions of quartz, sillimanite, and zircon are present and some grains have been altered to penninite with its anomalous blue interference color. Biotite crystals are arranged in such a way as to define the texture of the rock but also may be found in random orientation. These areas consist of quartz, microcline and biotite and are noticably lacking in sillimanite and garnet. The heaviest penninite alteration occurs where biotite orientation is least.

M-670 cont.

Both microcline and quartz have a great variation in grain size. The changes in grain size are related to to the degree of schistosity present; the smaller grains appearing where the foliation is strongest and the larger grains where there is no ordered arrangment. Tartan twinning and perthite can be found in microcline crystals of all sizes. Sericite alteration is moderate and does not affect all grains.

Quartz grains have slightly undulose extinction and have uneven to embayed grain contacts. Inclusions of sillimanite, biotite and zircon are present.

The garnets have neither well developed crystal facies or poikiloblasts. Grains are rather heavily fractured with no cleavage present. Although pressure shadows are not well developed, the bands of sillimanite and biotite are bent around the porphyroblasts. The largest garnet in this sample has a band of green muscovite running through a fracture in the crystal.

NUMBER M-671

NAME qtz-feld-biot-sil-schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	45	.45 mm	6.10mm / .04mm	xeno-blastic	biotite, sillimanite zircon			larger grains slow fractures	contacts even to embayed
Microcline	30/35	.40 mm	2.50mm / .12mm	xeno-blastic	biotite quartz	sericite	tartan		perthite
Biotite	15/20	.33 mm	1.10mm / .02mm	hypidio-blastic	zircon, quartz sillimanite opaques	penninite			
Sillimanite	5	.02 mm	.04mm / .01mm	idioblast fibrolite					
Muscovite	<1								minor alteration product
Zircon	<1								accessary

COMMENTS:

M-671

This sample of a boitite-sillimanite schist has been cut perpendicular to the direction of foliation. No foliation or schistosity is obersavable either microscopically or macroscopically. Biotite crystals appear mostly as "bookends" and the sillimanite grains have been cut perpendicular to the c-axis.

Quartz grains have a great range in size. The large grains can show heavy fracturing. Most grain contacts are uneven or embayed. Grains have wavy extinctions. Crystals of boitite, sillimanite and zircon occur as inclusions.

The potassium feldspar can be untwinned or exhibit the tartan twinning of microcline. Perthite texture also occurs in some grains. Inclusions of biotite and sillimanite are present. Graphic intergrowths with quartz are present in minor amounts. Alteration to sericite is found throughout the slide.

The biotite crystals are pleochroic in light brown to brown, however, a majority of grains have been altered to green penninite. Opaque minerals are found as inclusions and pleochroic halos from zircon crystals are present but rare.

Sillimanite occurs both as idioblastic crystals and in pods of fibrolite. Biotite and sillimanite are found together. In some cases the sillimanite can be seen replacing the biotite.

M-671 cont.

Muscovite is present in minor amounts and is associated either with biotite or the potassium feldspar.

NUMBER M-672

NAME qtz-biot-sil-feld-schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	40	.30 mm	1.80mm / .03 mm	xeno-blastic	biotite sillimanite zircon			highly fractured	contacts uneven to slightly suture
Biotite	30	.27 mm	1.00mm / .02 mm	hypidio-blastic	zircon sillimanite quartz opaques	penninite			
Sillimanite	20	.02 mm	.90mm / .01mm	idioblastic fibrolite					
Microcline	10	.30 mm	1.80mm / .03 mm	hypidio-blastic		sericite	tartan		
Zircon	<1			hypidio-blastic					accessory

COMMENTS:

M-672

Slide M-672 is a quartz-micrcline-biotite-sillimanite schist with a granoblastic fabric. The rock has well developed texture which is visible both macro- and microscopically, being defined by bands of sillimanite and biotite. These bands are not linear but have been bent into s-shapes due to polymetamorphism.

Quartz grains are randomly arranged without preferred orientation. Although a great range in size is present most grains tend to be large. Fracturing is common to most grains with exinctions being fairly even to slightly wavy.

Biotite is pleochroic in light brown to a dark reddish brown. Alteration to penninite affects about 25% of the grains. Opaque minerals contained in the slide occur included in or boardering biotite crystals. Other inclusions, of quartz, sillimanite and zircon, are also present. Most of the grains are arranged parallel to the foliation while others are quite random in their appearence. The penninite alteration is heaviest in these areas.

Sillimanite has a variation in size from fibrolite masses to idioblastic crystals approximately 1mm in length. The sillimanite commonly occurs intergrowing with quartz and biotite.

The potassium feldspar has been heavily altered to sericite. Because of this twinning and other internal structures are not easily seen. The feldspar is not evenly distributed . Most feldspar is found in areas with

M-672 cont.

poorly developed foliation.

NUMBER M-673

NAME qtz-feld-biot-sil-gar-schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35	.50 mm	3.00 mm / .02 mm	xeno-blastic	biotite sillimanite zircon			larger grains have fract.	contacts uneven to embayed
Microcline	15	.40 mm	1.80 mm / .06 mm	xeno-blastic	biotite quartz	sericite			perthite
Biotite	25	.70 mm	1.80 mm / .02 mm	hypidio-blastic	zircon sillimanite quartz opaques	penninite			
Sillimanite	25	.03 mm	1.28 mm / .01 mm	idroblastic fibrolite					
Almandine Garnet	2	4.50 mm		hypidio-blastic	muscovite in fractures				one garnet grain
Zircon	<1								accessory

COMMENTS:

M-673

The texture of this biotite-sillimanite-garnet schist is clearly seen both macroscopically and microscopically. The foliation is defined by the dark bands of sillimanite and biotite. The sample has a granoblastic fabric.

Quartz grains in this sample appear somewhat elongated in the direction of foliation. Grain to grain contacts are mostly uneven to slightly embayed. Grain extinction patterns are even to wavy and fracturing is present in the larger grains. Inclusions of biotite and zircon are present.

Biotite is pleochroic in light brown to dark brown with some alteration to green penninite. Inclusions of quartz, sillimanite, zircon and opaque minerals are seen. Both the size and orientation of the biotite grains vary throughout the slide, however, the larger percentage of crystals lie within the bands of foliation.

Sillimanite occurs as numerous fibrolite pods or as idioblastic crystals. These crystals may exist as individual grains or as porphyroblasts in pods of fibrolite. Most of the fibrolite pods have their lenticular shape lying parallel to the foliation. The order within the pods does not follow the rock structure. Growth of the sillimanite can be seen taking place at the expense of the biotite crystals.

M-673 cont.

The potassium feldspar is best seen by its perthitic texture or its alteration to sericite. The tartan twins of microline appear on a few grains but is not well developed. Inclusions of quartz, biotite and sillimanite are common. Sericite alteration is present but not heavy.

The garnets are hypidioblastic and have fracturing and moderately developed pressure shadows. Internal structures are limited to the outermost edges where some poikiloblasts of quartz are included in the grains. This would show that the last stages of garnet growth occurred during tectonism.

NUMBER M-674

NAME qtz-feld-biot-sil-schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	50	.45 mm	2.00mm / .03 mm	xeno-blastic	biotite zircon Sillimanite			minor fracturing	contacts even to sutured
Microcline	35	.44 mm	2.20mm / .06 mm	xeno-blastic	biotite quartz	sericite	tartan	minor fracturing	
Biotite	10	.24 mm	.80mm / .02 mm	hypidio blastic	opaques zircon quartz	penninite			
Sillimanite	5	.01 mm	.25mm / .01 mm	idioblastic fibrolite					
Zircons	<1	.04 mm	.07mm / .01 mm	hypidio-blastic					accessory

COMMENTS:

The texture of the quartz-microcline-biotite-sillimanite schist can be faintly seen microscopically but is best displayed by unaided examination of the slide. The granoblastic fabric has uniform grain size. The minor amount of alteration makes this a nice clear, crisp slide.

The quartz tends to have undulose extinction and very uneven to embayed contacts. Fracturing is not heavy and is more prominate in the larger grains. The grains commonly include biotite, sillimanite and zircon.

The microcline displays both perthite texture and tartan twinning. Alteration to sericite is minor and most often found along fractures. Biotite, sillimanite and quartz are included within the grains.

Biotite occurs mostly as individual grains with few grain to grain contacts with other biotite crystals. Pleochroism is light brown to brown. Opaque minerals, quartz, and sillimanite are found as inclusions along with zircon which causes pleochroic halos.

Sillimanite occurs in fine grained pods and lenticular masses which have their length oriented parallel to the schistosity. Fibrolite is found in most of these pods, however, masses of small individual crystals are present.

NUMBER M-675

NAME qtz-feld-biot-sil-gar. schist

FACIES Amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	25	.60 mm	1.70 mm / .02 mm	xeno-blastic	sillimanite biotite zircon			fractures moderate to heavy	contacts embayed to sutured
Microcline	25	.90 mm	2.10 mm / .06 mm	xeno-blastic	biotite quartz sillimanite	sericite	tartan		
Biotite	35	.45 mm	4.50 mm / .05 mm	hypidio-blastic	zircon quartz sillimanite	penninite			
Sillimanite	15/20	.03 mm	.90 mm / .01 mm	idioblastic fibrolite					
Almandine Garnet	2	4.00 mm	4.00 mm / .23 mm	xeno-blastic	microcline			fractures linear, subparallel	inclusions are not poikiloblasts
Zircon	<1		.27 mm / .02 mm	hypidio blastic					accessory
Apatite	<1			idio-blastic					accessory

COMMENTS:

M-675

Non-linear s-bends in the schistose structure mark this quartz-microcline-biotite-sillimanite schist. The individual crystals are not bent themselves, rather the bends are made by angling the grains. In places quartz has an elongate shape parallel to the foliation.

The quartz grains have uneven to embayed contacts. Fracturing is moderate but random, having a greater affect on the larger grains. Biotite, sillimanite and zircon inclusions are contained within the grains. Size of the grains varies in this sample.

The biotite crystals also have a wide range in size. Pleochroism is in light brown to brown with some grains showing alteration to green penninite. Inclusions of opaque minerals, quartz, and zircon are common. In places sillimanite inclusions are quite abundant.

Sillimanite occurs mainly in pods of fibrolite. These pods form lenses which follow the foliation. With the exception of one or two grains, the sillimanite crystals are all small and do not show the size differences of quartz and biotite.

The microcline is best seen when it displays either tartan twinning or perthite texture. Sericite alteration is present to a moderate degree. Inclusions of quartz, biotite and sillimanite can be found in many grains.

The hypidioblastic garnets are highly fractured and

M-675 cont.

broken. There are no internal structures . Pressure shadows around the larger grains are poorly developed and best seen under uncrossed nicols.

NUMBER M-676

NAME sil-biot-gar-schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Sillimanite	25	.06 mm	.40mm / .01mm	idioblastic fibrolite				fractures perpendicular to length	
Biotite	65	2.20 mm	4.7mm / .03mm	hypidio-blastic	zircon opaques quartz sillimanite				
Quartz	3	.12 mm	1.35mm / .01mm	xeno-blastic	zircon biotite				
Microcline	2	.25 mm	.39mm / .15mm	xeno-blastic		sericite			highly sericitized
Almandine Garnet	3	4.50 mm	4.50mm / —	hypidio-blastic	quartz, biotite in fractures			random fractures	pressure shadows
Zircon	2	.06 mm	.12mm / .01mm					random fractures	accessory

COMMENTS: only one garnet

M-676

M-676 is a biotite-sillimanite schist with well developed texture. The bands of minerals are arranged parallel to each other bending around a lone garnet porphyroblast.

Biotite is pleochroic in light brown to brown with a heavy concentration of pleochroic halos. Sillimanite and quartz are included within the grains. No alteration is present.

Sillimanite occurs in lenticular pods of fibrolite and as indivdual, idioblastic grains. The size of the sillimanite crystals is quite small especially when compared to the coarse biotite grains.

The garnet porphyroblast has a hypidioblastic shape with no internal order visible. The grain is fractured but is not broken apart. The pressure shadow around the garnet contains most of the quartz and microcline found in the slide.

Small intergranular quartz is present throughout the sample.

NUMBER M-677

NAME qtz-biot-sil-schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	40	.80 mm	1.40mm /.03 mm	xeno-blastic	zircon sillimanite biotite			fractures ⊥ to foliation	contacts uneven to slight sutured
Microcline	10	.39 mm	2.10mm /.06 mm	xeno-blastic	quartz biotite	sericite			perthite
Biotite	30	.40 mm	1.80mm /.01 mm	hypidio-blastic	zircon quartz sillimanite	penninite			
Sillimanite	20	.03 mm	.10mm /.01 mm	idioblastic fibrolite					
Zircon	<1								accessory

COMMENTS:

The schistosity of this quartz-biotite-sillimanite-microcline schist is shown by the orientation of the biotite and sillimanite crystals and by the elongation of the quartz grains in the direction of the foliation. The fabric of the rock is granoblastic.

The quartz grains have a distinct elongation parallel to the foliation. Also noticeable are the fractures which run parallel to each other and intersect the lineation at about a 60° angle. The grain contacts for the quartz range from embayed to slightly sutured. The grains have inclusions of biotite, sillimanite and zircon.

Biotite is pleochroic in brown to light brown with some alteration to green penninite. Inclusions of zircon cause pleochroic halos. Quartz and sillimanite are also found within the grains. The majority of the biotite is aligned parallel with the foliation, however, there are areas of randomly arranged crystals. Here the concentration of the biotite is less and the penninite alteration is greater.

Sillimanite is rather uniform in size occurring in lenses . A large portion of these structures are made of idioblastic grains. Where fibrolite was contained at the center of these masses, voids are present. It is possible that the fibrolite there was removed during the slide preparation.

The potassium feldspar is a minor member of the

M-677 cont.

slide. The grains display perthite tecture and rartan twinning. Quartz and biotite are included in the grains and many crystals show sericite alteration.

NUMBER M-678

NAME feldspathic-quartzite

FACIES

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	65	5.00 mm	9.00mm / .02 mm	xeno-blastic				random fractures	sutured contacts
Feldspar	35	5.00 mm	9.00mm / .14 mm	xeno-blastic	quartz	sericite	tartan albite	random fractures	
Muscovite	<1	.40 mm	.60 mm / .08 mm	hypidio blastic					minor

COMMENTS:

M-678

M-678 is a very coarse grained granite-gneiss. Made almost entirely of quartz and feldspar, muscovite is the only other mineral present and amounts to only two small grains in this slide.

The quartz grains have highly sutured contacts, are moderately fractured and have wavy extinction.

The feldspars show faint albite twinning, tartan twinning and perthite texture indicating both potassium and soda-rich feldspars are present. Extinction angles on the albite twins of 6°-8° would classify them as oligoclase. However, sericite alteration is heavy on these grains making precise measurements difficult.

NUMBER M-679

NAME qtz-feld-biot-sil-schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35/40	.80 mm	1.40 mm / .02 mm	xeno-blastic	biotite sillimanite zircon			random fracturing	contacts uneven to sutured
Microcline	10/15	.60 mm	1.80 mm / .04 mm	xeno-blastic	quartz biotite	sericite	tartan		perthite
Biotite	25/30	.60 mm	1.60 mm / .02 mm	hypidio blastic	zircon quartz sillimanite	penninite			
Sillimanite	15	.07 mm	.80 mm / .01 mm	idioblastic fibrolite					
Zircon	<1								accessory

COMMENTS:

M-679

The sample is a quartz-sillimanite-biotite-microcline schist. Foliation is visible both macro- and micro scopically. Oriented grains of biotite, sillimanite and quartz define the texture. The bands are parallel to each other but are not linear.

The quartz grains are elongated in the direction of the foliation. Fracturing is present but random and does not affect every grain. Grain contacts range from uneven to embayed. Inclusions of biotite, sillimanite and zircon can be found.

The biotite is pleochroic in yellow-brown to dark greenish—brown. Alteration to penninite can be found where the biotite shows the least amount of orientation. The crystals are not bent with the foliation, rather bends are made of indiviual grains. Biotite crystals contain inclusions of quartz, sillimanite and zircon.

Sillimanite can be found in lenticular pods or as individual crystals, both of which follow the foliation. The lenses contain fibrolite at their center. The idioblastic grains show a great range in size although the majority are small. A large number of these idioblastic crystals are cut perpendicular to the c-axis.

The microcline in this sample displays perthite texture and tartan twinning. Many of the grains are untwinned. Biotie,sillimanite and quartz are common inclusions. Sericite alteration appears in many grains.

NUMBER M-680

NAME Tremolite-Biotite schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Tremolite Actinolite	70	.80 mm	4.60 mm / .15 mm	hypidio-blastic	quartz biotite apatite		simple		
Biotite	25	.60 mm	2.29 mm / .10 mm	hypidio-blastic	zircon quartz				
Quartz	5	.05 mm	.08 mm / .03 mm	xeno-blastic	zircon				
Zircon	<1	.01 mm	.08 mm / .02 mm	hypidio-blastic					accessory
Apatite	<1			idio-blastic					accessory

COMMENTS:

M-680

This tremolite-biotite schist has well developed schistosity with a granoblastic fabric. Tremolite and biotite show linear alignment best seen microscopically.

The tremolite crystals have faint green pleochroism. Some grains are idioblastic with the characteristic amphibole outline. Simple twinning is revealed under crossed nicols. Quartz inclusions can be found in many of the grains. In crystals cut perpendicular to the c-axis, and where the two directioal cleavage is well developed, the centers of the grains have been removed during the slide preparation.

The biotite is pleochronic in light brown to brown with inclusions of quartz and zircon. The zircon grains are accompanied by pleochroic halos.

Quartz is a minor constituent in the sample. The grains are small, without fractures and show even extinction. They occur as inclusions in other grains or intersitially between grains.

NUMBER M-681

NAME qtz-biot-sil-feld schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quarte	55/60	.70mm	1.20mm /.03mm	xeno-blastic	zircon biotite sillimanite			very minor	contacts embayed, triple points
Microcline	15/20	.40mm	.70mm /.07mm	xeno-blastic	quartz biotite zircon	sericite	tartan	minor	graphic quartz intergrowth
Biotite	15	.12mm	1.00mm /.01mm	hypidio-blastic	zircon opaques	penninite			
Sillimanite	5/10	.03 mm	.12mm /.01mm	idioblastic fibrolite					
Zircon	<1	.03 mm	.08mm /.01mm	hypidio-blastic					accessory

COMMENTS:

M-681

This quartz-biotite-sillimanite-microcline schist has granoblastic texture and is very similar to slide M-674. The schistosity is best seen in the uniform orientation of the biotite grains and the elongation of the sillimanite pods.

The quartz, biotite and microcline grains are fairly equigranular. The quartz grains are mostly free of fractures and have embayed contacts and even extinction patterns. Inclusions of biotite, sillimanite and zircon are common.

The microcline is readily indentifiable by its tartan twinning. Not all of the grains show these twins however, and untwinned feldspar can be recognized by minor sericite alteration along fractures. Inclusions of biotite and quartz are common, less so with sillimanite.

Biotite is pleochroic in light brow to brown. Some of the crystals have been altered to green penninite. Inclusions of zircon have caused pleochroic halos. The biotite is equally distributed throughout the slide, occurring more as individual grains than in groups of crystals.

Sillimanite on the other hand is always found in groups forming lenticular pods. These pods may be made entirely of idioblastic grains or may have fibrolite at their center. Grain size for sillimanite is fairly uniform.

NUMBER M-682

NAME qtz-feld-biot-sil schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	55/60	.70mm	1.40mm /.02mm	xeno-blastic	zircon, sillimanite biotite, microcline			increased fracture near sillimanite	contacts embayed to slight suture
Microcline	15/20	.60mm	4.40mm /.02mm	xeno-blastic	sillimanite quartz biotite	sericite	tartan	moderate fractures	perthite
Biotite	15	.23mm	1.60mm /.03mm	hypidio-blastic	zircon	pennine			
Sillimanite	5/10	.03mm	.12mm /.01mm	idioblastic fibrolite					
Zircon	<1	.03mm	.07mm /.01mm	hypidio-blastic					accessory

COMMENTS:

M-682

M-682 is a quartz-microcline-biotite-sillimanite schist with granoblastic texture. The schistosity is best shown by the biotite and sillimaite grains. Some quartz grains are also elongate in the direction of schistosity.

Quartz grains are fractured with wavy extinction patterns. Grain contacts are uneven to slightly sutured. Many inclusions of sillimanite give quartz crystals a dirty appearence. Inclusions of biotite and sillimanite can also be found.

The feldspar grains show the tartan twinning of microcline and some show perthite texture. Not all of the feldspars show twins. Untwinned grains can be identified by sericite alteration along fractures in the grains.

Biotite is pleochroic in light brown to brown with discoloration caused by zircon's pleochroic halos and alteration to penninite. Biotite groups are found together with sillimanite; individual grains are distributed throughout the slide.

Sillimanite pods are large with lenticular shape. The centers of these masses contain fibrolite which have been removed, in some cases, during slide preparation. Idioblastic crystals are of uniform size.

The garnet grains are restricted to only two

M-682 cont.

porphyroblasts in this sample. The grains are fractured and do not contain poikiloblasts of other minerals.

NUMBER M-683

NAME qtz-feld-biot-sil-gar schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	30	.20 mm	1.30 mm / .03 mm	xeno-blastic	biotite apatite sillimanite zircon			random fracturing	contacts even to sutured triple points
Microcline	20/25	.25 mm	4.00 mm / .03 mm	xeno-blastic	quartz biotite sillimanite apatite	large amount of sericite	tartan		perthite
Sillimanite	15/20	.02 mm	.40 mm / .01 mm	idioblastic fibrolite				fractures ⊥ to length	
Biotite	25	.22 mm	4.40 mm / .03 mm	hypidio-blastic	zircon sillimanite quartz	penninite			
Almandine Garnet	2	1.80 mm	4.10 mm / .03 mm	hypidio-idio-blastic	quartz			highly shattered	well developed pressure shadows
Apatite	<1	.04 mm	.08 mm / .01 mm	idio-blastic					accessory
Zircon	<1	.03 mm	.07 mm / .01 mm						accessory

COMMENTS:

This quartz-microcline-sillimanite-biotite-garnet schist has poorly developed schistose character. Grains of biotite do show preferred orientation with uncrossed nicols, however, this pattern is not strong.

In a few areas quartz grains are elongate in the direction of the biotite and sillimanite orientation, however, for the most part, the grains are randomly arranged. The unfractured grains are equidimensional and have wavy extinction. Grain contacts range from even to embayed. Sillimanite and biotite inclusions are common with occassional zircon.

The potassium feldspar has microcline's tartan twinning perthite texture or is untwinned. Alertation to sericte is heavy. Sillimanite, biotite and quartz are contained as inclusions.

Biotite has a great variety of size, orientation and degree of alteration to penninite. The largest crystals are located near garnet porphyroblasts. The crystals are pleochroic in light brown to brown. Pleochroic halos are present. Sieve-like texture is created by intergrowths with sillimanite.

Sillimanite pods do not form lenticular shapes. This might indicate that the slide was cut perpendicular to the foliation of the rock. Both fibrolite and idioblastic grains are present. Some of the largest crystals

are found inside of the fibrolite masses. Groups of coarse-grained sillimanite occur together cut perpendicular to the c-axis.

The garnets are ringed by biotite and sillimanite grains. This feature is visible both macro- and microscopically. The porphyroblasts are fractured and broken apart and have xenoblastic shape.

Muscovite is also found as an alteration product of biotite and feldspar.

NUMBER M-684

NAME qtz-feld-biot-sil gar schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	25	.35 mm	2.10mm / .03 mm	xeno-blastic	biotite zircon apatite biotite Sillimanite			random fractures	contacts uneven to slight sutured
Microcline	20	.40 mm	4.50mm / .05 mm	xeno-blastic	quartz apatite biotite zircon sillimanite	Sericite	tartan		perthite
Biotite	25	.20 mm	2.30mm / .03 mm	hypidio blastic	zircon sillimanite quartz	penninite			
Sillimanite	29/25	.10 mm	.80mm / .01mm	idioblastic fibrolite					
Almandine Garnet	5/10	1.70 mm	4.50mm / .02mm	Xenoblastic, small grains idioblast				larger grains fractured	good pressure shadows
Zircon	<1	.03 mm	.08mm / .01 mm	hypidio blastic					
Apatite	<1	.04 mm	.07mm / .01 mm	idio blastic					

COMMENTS:

M-684

This quartz-microcline-biotite-sillimanite-garnet schist has granoblastic texture. The orientation of grains is displayed by the parallel arrangement of biotite and lenticular pods of sillimanite. There is a great range of size present in all the grains.

Quartz occurs in a variety of ways. The most common form is unfractured grains with slightly wavy extinction. Contacts are uneven to embayed. Grains associated with the sillimanite pods can be elongate in the direction of foliation. In the pressure shadows of garnet crystals, quartz can be found in graphic intergrowths with feldspar and biotite. This quartz is unfractured and has even extinction.

The microcline grains also have a number of shapes. Large grains of 4.5mm fill the field of view when examining the thin-section. Tartan twins and perthie structures are present in some grains. Other grains are untwinned but have sericite alteration along fractures in the grains.

Biotite is pleochroic in light brown to brown with penninite alteration and pleochroic halos. The largest biotite crystals are located in the pressure shadows of the garnets. Inclusions of sillimanite and quartz give some grains sieve-like texture.

The sillimanite grains best illustrate the foliation. The deformation is not linear but is made of s-type bends and chevron folds.

M-684 cont.

The garnet porphyroblasts are xenoblastic. Heavy fracturing can be seen with uncrossed nicols. There are no poikiloblasts or internal structures, however, minerals have entered the grains along fractures. Pressure shadows around the crystals are well developed.

NUMBER M-685

NAME qtz-biot-feld-sil-gar schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	30	.50 mm	2.80mm / .03 mm	xeno blastic	biotite sillimanite zircon			random fractures	contacts uneven embayed
Biotite	25	.50 mm	2.50mm / .02 mm	hypidio blastic	zircon opaques quartz sillimanite	penninite			
Sillimanite	20	.06 mm	2.20mm / .01 mm	idioblastic fibrolite				fractures on largest grains	
Microcline	15	.40 mm	2.80mm / .04mm	xeno blastic	quartz biotite sillimanite	sericite (slight)	tartan Carlsbad	random fractures	
Almandine Garnet	10	2.60 mm	4.70mm / .50 mm	hypidio blastic				fractured	pressure shadows
Zircon	<1								accessory

COMMENTS:

M-685

This slide is the same as M-684. The severity of the deformation is less with the bands of foliated grains being more linear in arrangement.

NUMBER M-686

NAME qtz-feld-biot-sil-gar schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35	.50 mm	1.60 mm / .06 mm	xeno blastic	biotite sillimanite zircon Sillimanite			random fractures	contacts uneven to embayed
Microcline	25	.07 mm	2.00 mm / .03 mm	xeno blastic	quartz biotite sillimanite	sericite	tartan	some fractures	perthite
Biotite	20/25	.60 mm	1.70 mm / .05 mm	hypidio blastic	zircon opaques quartz	penninite			
Sillimanite	15	.04 mm	.40 mm / .01 mm	idioblastic fibrolite					
Almandine Garnet	5/10	1.30 mm	3.70 mm / .02 mm	hypidio blastic	quartz poikiloblasts	green muscovite along fractures		fractures light to heavy	

COMMENTS:

M-686

This slide has been cut perpendicular to the foliation so that no banding or lineation is present. The groups of sillimanite are not in lenticular pods but are grouped together without orientation. Biotite also has a random appearence with grains showing varying degrees of pleochroism under uncrossed nicols. The overall texture is lepidoblastic.

Quartz grains range from those with smooth contacts and even extinction patterns to sutured edges and and wavy extinction. Fracturing is present in some grains but is not heavy. Included within the quartz are biotite, sillimanite and zircon.

Tartan twinning and perthite texture is common in the microcline present. Sericite alteration is heavy in some grains. Graphic inclusions of quartz as well as inclusions of biotite and sillimanite can be found.

Biotite is pleochroic in light brown to brown. Green penninite alteration affects many grains. Intergrowths with sillimanite create sieve textures in some crystals.

Sillimanite does not have a great range in size. Both fibrolite and idioblastic crystals are frequently associated with biotite. In some areas, the grains are arranged in chevron-type folds.

M-686 cont.

Garnet crystals contain poikiloblasts of quartz. These occur at the center of the grains but do not have any preferred orientation. Not all of the garnet porphyroblasts contain these poikiloblasts. Garnet shapes range from idio- to xenoblastic with most grains being heavily fractured.

NUMBER M-687A

NAME qtz-feld-biot-sil-gar schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35	.60 mm	2.00mm /.03mm	xeno blastic	sillimanite biotite zircon			random fractures	contacts uneven embayed sutured
Microcline	25	.50 mm	4.00mm /.10 mm	xeno blastic	biotite zircon quartz sillimanite	sericite (minor)	tartan	some fractures	perthite
Biotite	20/25	.80 mm	2.20mm /.05mm	hypidio blastic	zircon opaques	penninite			
Sillimanite	15/20	.03mm	.60mm /.01mm	idioblastic fibrolite					sharp chevron folds
Almandine Garnet	3	1.50 mm	4.7mm /1.0mm	xeno blastic	quartz poikiloblasts	green muscovite			
Muscovite	<1	.40 mm	.65mm /.25mm	hypidio blastic					near garnet
Zircon	<1								accessory

COMMENTS:

M-687a

This sample shows a quartz-micrcline-biotite-sillimanite-garnet schist with lepidoblastic fabric. The orientation of biotite and sillimanite is limited in extent and at no one place can a single band be followed across the slide. Both macro- and microscopically, the chevron folds of polymetamorphism can be seen.

Quartz grains have uneven to embayed contacts with undulose extinction. Fracturing is not present in all grains. Crystals include grains of biotite, sillimanite and zircon. Graphic intergrowths of quartz and feldspar can be found.

The potassium feldspar shows both microlcline's tartan twinning and perthite texture. A great range in size of feldspar grains is present with some areas having large, almost porphyroblastic crystals. Sreicite alteration is also present.

Biotite is pleochroic in brown to light brown with penninite alteration and pleochroic halos. Sieve texture has developed from intergrowths with sillimanite.

Sillimanite has many large cyrstals cut perpendicular to the c-axis. In several of the large pods of fibrolite, the centers have been removed during the preparation of the slide.

M-678a cont.

Garnet crystals can be either idioblastic or xenoblastic in shape. Fracturing affects all of the garnets with some of the grains being shattered and dislocated. Poikiloblasts of quartz are restricted to only one crystal. No pressure shadows are developed around the grains.

NUMBER M-687B

NAME qtz-feld-biot-sil-gar schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	40	.60 mm	2.90mm /.05 mm	xeno blastic	sillimanite biotite zircon			random fracturing	contacts uneven embayed sutured
Microcline	15	.60 mm	3.00 mm /.07 mm	xeno blastic	quartz sillimanite biotite	sericite	tartan		perthite
Biotite	20	.45 mm	1.50 mm /.03 mm	hypidio blastic	zircon sillimanite quartz	penninite			
Sillimanite	15	.08 mm	1.20 mm /.01 mm	idioblastic fibrolite	quartz				fibrolite minor
Almandine Garnet	10	2.20 mm	2.5 mm /.25 mm	hypidio blastic	quartz poikiloblasts biotite			moderate fracturing	
Zircon	<1								

COMMENTS:

M-678b

This slide has the same overall texture and composition as M-678a. Differences between the two slides include the higher percentage of garnet and heavier penninite alteration in M-678b.

NUMBER M-688

NAME feldqtz-hornb-amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	25	.70 mm	1.90mm / .04 mm	Xeno blastic	quartz sphene plagioclase	biotite	simple twins	fractures and cleavage	
Plagioclase	55	.70 mm	1.50mm / .04 mm	Xeno blastic	hornblende sphene apatite quartz	sericite	albite carlsbad pericline		
Quartz	10	.65 mm	1.60mm / .08 mm	Xeno blastic	sphene apatite hornblende				embayed contacts
Diopside	7	1.50 mm	1.90mm / .40 mm	Xeno blastic	quartz	biotite hornblende		parting present	
Sphene	3	.15 mm	.25mm / .02 mm	Xeno blastic					
Apatite	<1			idio, blastic					accessory

COMMENTS:

Plagioclase, hornblende and diopside are the major minerals in this quartz-rich amphibolite. The granoblastic texture does not have any preferred crystal orientation.

The hornblende is pleochroic in yellow-green to a slightly blueish-green. The individual grains have well defined boundaries making each grain easily identifiable. Neither cleavage or fracturing is very prominate leaving the grains with a clear appearence. Quartz, sphene and apatite are notable inclusions.

Diopside has been altered to brown biotite and hornblende. Parallel parting can be seen in the grains. The diopside is not uniformly distributed in the sample but is clustered together in a single area.

Quartz grains have uneven to embayed contacts. Most grains have undulose extinction patterns but are free of fractures. Sphene, apatite and hornblende are found as inclusions.

The feldspars can be either twinned or untwinned. Albite, pericline and tartan twinning are present indicating that both potassium and soda-rich feldspars are present. Sericite alteration is present in most but not all grains. This and the lack of well developed twinning make exact compositions of the

M-688 cont.

grains difficult to obtain. However the majority of the grains seem to be soda-rich plagioclase with very minor amounts of tartan twinning present.

NUMBER M-689

NAME qtz-feld-biot-sil-gar schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35	.70 mm	10.00 mm / .03 mm	xeno blastic	sillimanite biotite zircon			random fractures	contacts uneven to embayed
Microcline	25	4.00 mm	7.20 mm / .07 mm	xeno blastic	quartz, sillimanite biotite zircon	sericite	tartan		perthite
Biotite	20/25	.80 mm	2.10 mm / .04 mm	hypidio blastic	zircon quartz, sillimanite	penninite			
Sillimanite	15	.05 mm	.80 mm / .01 mm	idioblastic fibrolite					
Almandine Garnet	5	2.00 mm	4.00 mm / .06 mm	hypidio blastic	quartz poikiloblasts	green chlorite		some highly fractured	pressure shadows
Muscovite	<1								minor
Zircon	<1								accessory

COMMENTS:

M-689

This rock has two distinct textures. The majority of the sample is a biotite-sillimanite-quartz schist. Feldspar is a minor member in this area. Thirty per cent of the slide consists of large porphyroblasts of feldspar crystals.

The coarse microcline grains are either untwinned or show tartan twinning. Sericite alteration can be heavy but does not affect every grain. Muscovite and biotite are found as inclusions.

The quartz grains have a great range in size. Large elongate grains boarder the feldspar porphyroblasts and run parallel to the sillimanite-biotite orientation. Most of the grains in the sillimanite-biotite region are elongate in the direction of schistosity. These crystals are fractured perpendicular to their length and have uneven to embayed contacts. Between the coarse microcline grains are smaller, unoriented quartz grains which have smooth grain contacts and even extinction. The grains include biotite, sillimanite and zircon.

Biotite is pleochroic in light brown to brown. Penninite alteration is is heavier in some parts of the slide than in others. Zircon, quartz, and sillimanite are contained as inclusions.

Sillimanite occurs in thick bands of mostly idioblastic crystals cut perpendicular to the c-axis.

M-689 cont.

Fibrolite is contained in these bands but does not form lenticular pods. Grain size of the sillimanite is fairly uniform.

Garnet porphyroblasts are found in the sillimanite-biotite section. The shape of the grains vary from hypidioblastic to xenoblastic. All of the garnets are heavily fractured. Poikiloblasts of quartz appear at the core of the crystals without displaying any pre-existing structure. Pressure shadows are not well developed. Alteration to chlorite is also present.

NUMBER M-690

NAME Hornb-plag-epid-amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	55	1.00 mm	3.00mm / .05mm	hypidio blastic	plagioclase	biotite			
Andesine	40	.12 mm	1.80mm / .07mm	xeno blastic	epidote hornblende	sericite	albite carlsbad		
Epidote	5/10	.25 mm	.50mm / .04 mm	hypidio blastic				random fractures	
Biotite	<1	.50mm		hypidio blastic	opaques	pennine			minor

COMMENTS:

M-690

This hornblende-plagioclase-epidote amphibolite has an alignment of hornblende grains giving the rock a nematoblastic fabric.

The hornblende is pleochroic in yellow-green to an olive or dark green. There is a slight alteration of the grains to biotite but no reaction rims are present.

Albite twinning is most common in the plagioclse but Carlsbad and pericline twinning can also be seen. Extinction angles of 25°-25° put the composition of the plagioclase in the andesine range. Hornblende, epidote and sericite alteration are found within the grains.

Epidote is a minor member but equally distributed throughout the slide. Some crystal outlines are present but most of the grains are xenoblastic.

NUMBER M-691

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	30	.30 mm	5.00 mm / .07 mm	xeno blastic	biotite zircon apatite			Some random fractures	Contacts embayed sutured
Biotite	20	.20 mm	1.20 mm / .05 mm	hypidio blastic	zircon	green chlorite			
Microcline	40	.75 mm	9.00 mm / .06 mm	xeno blastic	quartz biotite apatite zircon	sericite	tartan		
Epidote	2	.15 mm	.30 mm / .05 mm	xeno blastic				highly fractured	
Apatite	<1			idio blastic					accessory
Muscovite	<1								a few grains near large feldspar

COMMENTS:

M-691

This sample is a granite-gneiss with two distinct textures. Half of the slide is a granoblastic array of of quartz, feldspar and biotite with minor amounts of epidote. The other half has extremly coarse grains of quartz and a feldspar which is mostly microcline. Biotite is present in veins, intermixed with quartz and microcline, which run between the coarser grains.

The quartz grains have undulose extinction with minor fracturing. Grain contacts are uneven to embayed. Biotite, epidote and apatite are inclusions.

Feldspar in the finer grained section have albite twins with 10°-10° extinction angles of oligoclase. Pericline and carlsbad twins are also present although not all grains show twinning. In the coarser grained area microcline is dominate. Inclusions of quartz and biotite as well as sericite alteration appear in the grains.

Biotite is pleochroic in yellow-brown to olive brown in color. Orientation of the grains is not well developed. The grains edges are not sharply defined. Minor chlorite alteration is seen with uncrossed nicols.

NUMBER M-692

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Microcline	55	.70 mm	9.00mm /.10mm	xeno blastic	quartz(graphic)	sericite (extensive)	tartan		
Quartz	40	1.80 mm	5.00mm /.07mm	xeno blastic				random fractures	
Biotite	5	.25 mm	.90mm /.02mm	hypidio blastic	opaques	heavy penninite alteration			
Muscovite	<1								

COMMENTS:

M-692

M-692 is a coarse grained granite-gneiss. No orientation of the grains is present . Most grains are large enough to fill the field of view.

The quartz grains have sutured contacts. Fracturing is present but not heavy and the grains have wavy extinction. By and large the grains are free of inclusions with only minor biotite present.

The potassium feldspars have two size groups. The smaller grains have microcline's tartan twins and tend not to be altered to sericite. The larger grains do not have the well developed tartan twinning but have perthite texture. Sericite alteration is considerable. Both muscovite and biotite are inclusions as well as quartz.

Biotite is a minor member. Alteration to penninite is common and in come cases affects the entire grain.

NUMBER M-693

NAME hornb-plag-qtz amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35	.45 mm	2.00 mm / .03 mm	xeno blastic	apatite				contacts even to embayed
Hornblende	30	.50 mm	1.80 mm / .03 mm	xeno blastic	quartz apatite sphene opaques	biotite	{100} twin plane	{110} 2 direction irreg fractures	some qtz poikiloblasts
Oligoclase	25	.40 mm	1.30 mm / .03 mm	xeno blastic	quartz apatite	sericite	albite pericline		
Sphene	3	.05 mm	.07 mm / .03 mm	xeno blastic	opaques				clinozoisite also present
Apatite	1	.05 mm	.07 mm / .02 mm	idio blastic					accessory
Epidote	<1	.07 mm	1.00 mm / .01 mm	xeno blastic					minor
Opaques	7/10								

COMMENTS:

M-693

This is a quartz-hornblende-plagioclase schist with nematoblastic fabric. Somewhat parallel banding of the grains can be detected with the unaided eye but does not appear under the microscope.

Quartz grains have uneven to embayed contacts and for the most part are free of fractures. Extinctions are wavy and the grain sizes are uniform. Apatite is included within the grains as are sphene, hornblende and epidote.

The plagioclase has sericite alteration. Albite, pericline and carlsbad twinning are displayed. Extinction angles are difficult to obtain as the albite twins are not clear and sharp. Measurements of 8°-8° would put the plagioclase in the range of oligoclase. The twin lamalle in some grains have deformation curves.

Hornblende is pleochroic in yellow-green to dark green. The crystals are darkened by fractures and brown biotite alteration. Crystal outlines are very indistinct although no reaction rims are present. No clear orientation of the grains is visible.

Sphene occurs in groups of grains which often contain opaques. Cleavage is not well developed within the grains nor is the crystal shape.

Epidote ranges from moderate to fine xenoblastic grains. Apatite is plentiful and idioblastic.

NUMBER M-694

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	40	1.00 mm	6.00 mm / .05 mm	xeno blastic	apatite biotite zircon			fracturing minor	contacts uneven slight embayed
Plagioclase Microcline	45	.40 mm	1.30 mm / .05 mm	xeno blastic	apatite quartz zircon biotite	sericite		carlsbad albite	
Biotite	10	.45 mm	1.50 mm / .04 mm	xeno blastic	opaques zircon	penninite chlorite			
Epidote	<1	.17 mm	.27 mm / .01 mm	xeno blastic				heavy fractures	
Zircon	<1	.07 mm	.18 mm / .01 mm						accessory
Muscovite	<1								altered feldspar
Apatite	<1	.05 mm	.13 mm / .02 mm	idio blastic					

COMMENTS: Lazulite grain present

Opaques 5%

M-694

This granite-gneiss has granoblastic texture and consists of quartz, plagioclase, and biotite. The elongation of quartz grains and the orientation of the biotite create a parallel fabric in the rock.

The quartz grains are dirty with microlite inclusions. The grain contacts range from uneven to slightly sutured and there is minor fracturing. Biotite and apatite inclusions can be identified. Grain size is uniform in much of the slide with large almost porphyroblastic quartz grains located in a corner of the slide.

Albite, pericline and Carlsbad twins are contained in the plagioclase however none of the twins are usuable to determine anorthite content of the crystals. Sericite alteration is present.

Biotite is pleochroic in brown. The grains contain opaque minerals and penninite alteration. Quartz is also included in the grains. Crystal edges are not distinct in this sample.

Apatite and epidote appear as accessory grains. Apatite has both idioblastic and hypidioblastic shapes. The epidote is restricted to a few xenoblastic grains.

NUMBER M-695

NAME hornb-plag-qtz. amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	60/65	.50 mm	1.70 mm/.04 mm	xeno blastic	quartz apatite	biotite			
Quartz	10	.60 mm	1.00 mm/.03 mm	xeno blastic	apatite				contacts even
Plagioclase	25/30	.50 mm	1.3 mm/.03 mm	xeno blastic	quartz hornblende apatite	sericite	albite pericline	minor fracturing	
Sphene	5	.16 mm	.41 mm/.02 mm	xeno blastic	opaques				
Epidote	<1	.10 mm	.30 mm/.06 mm						
Apatite	<1	.07 mm	.12 mm/.04 mm						accessory

COMMENTS:

M-695

Parallel bands create a schistose texture in this hornblende-palgioclase-quartz amphibolite. This orientation of the amphibole grains gives this rock a nematoblastic fabric. All of the major minerals have similar grain sizes.

The hornblende is pleochroic in yellow-green to a dark olive-green. The grain edges are sharp and without reaction rims. Quartz and plagioclase are found as inclusions. The grains are darken by heavy cleavages and fractures.

The plagioclase has albite and pericline twinning. Albite extinction angles measure 19°-18° , in the soda-rich range of the plagioclases. The twin lamalle are fine and in some cases curved. Quartz, hornblende and epidote occur as inclusions. Sericite alteration is minor and does not affect all of the grains.

The quartz grains are unfractured, have even to slightly wavy extinction and have smooth grain contacts. Hornblende and epidote are the major inclusions.

NUMBER M-696

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	50	1.10 mm	2.70 mm/.03 mm	Xeno blastic					
Microcline/Plagioclase	35	.85 mm	1.90 mm/.05 mm	Xeno blastic	quartz biotite	sericite	tartan albite		
Biotite	10	.40 mm	2.00 mm/.04 mm	Xeno blastic	zircon opaques				
Epidote	<1								minor
Opaques	3								
Apatite	<1			hypidio blastic					accessory

COMMENTS:

M-696

This granite-gneiss has granoblastic texture. The minerals making up this rock are quartz, feldspar and biotite. The grains are of fairly uniform size.

Quartz grains are moderately fractured with embayed contacts. The extinction patterens are wavy. Inclusions of biotite and some feldspar are present.

Both potassium and soda-rich feldspars appear in the slide. Tartan twinning is clearly seen on some grains while in others pericline twins and fine albite twins are present. Graphic inclusions of quartz are present as well as inclusions of biotite. Sericite alteration is present in minor amounts.

Biotite is pleochroic in light brown to brown. Grain edges are not sharply defined although penninite alteration is light. No grain orientation is present. Minor amounts of zircon inclusions form pleochroic halos.

A small percentage of epidote is also present in the slide.

NUMBER M-697

NAME hornb-plag amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	60	.80 mm	2.10 mm/.05 mm	xeno blastic	opaques plagioclase biotite	biotite		heavy parting	
Plagioclase	30	.60 mm	1.80 mm/.06 mm	xeno blastic	hornblende epidote	sericite	albite carlsbad pericline		
Epidote	10	.40 mm	.80 mm/.03 mm	xeno blastic					

COMMENTS:

M-697

Hornblende, plagioclase and epidote are the principle minerals in this amphibolite. The granoblastic texture does not show any preferred orientation of the grains.

Horblende in this sample is pleochroic in yellow green to green but heavy alteration hides both color and crystal form. Opaques, plagioclase and biotite can be found as inclusions, along with epidote.

The plagioclase has pericline, carlsbad and albite twinning. Andesine composition is indicated by 14°-14° extinction angles. Epidote, apatite and hornblende are included along with sericite alteration.
The plagioclase is not as heavily altered as the hornblende.

Epidote crystals show both high interference colors and anomalous blue colors indicating two types of epidote are present.

NUMBER M-698

NAME hornb-plag-qtz amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	60	1.00 mm	1.80 mm / .03 mm	xeno blastic	quartz apatite opaques sphene	epidote	simple	{110} 2 direct cleavage irreg. fractures	
Plagioclase	25			xeno blastic	quartz hornblende	sericite	albite		
Quartz	10	.15 mm	.60 mm / .02 mm	xeno blastic	sphene hornblende apatite				
Epidote	3	.09 mm	.45 mm / .03 mm	xeno blastic					
Sphene	2	.03 mm	.08 mm / .01 mm	xeno blastic					
Apatite	<1	.02 mm	.04 mm / .01 mm	idio blastic					

COMMENTS: sericite alteration of feldspar too intense to determine grain sizes

M-698

The faint texture of this hornblende-plagioclase-quartz amphibolite can be decerned microscopically but is best seen macroscopically. A granoblastic fabric is displayed in this sample.

Hornblende is pleochroic in yellow-green to dark green and is spotted by inclusions of quartz. Grains boundaries are sharp and without reactions rims.

The plagiclase grains have been so highly sericitized that the faintest of albite twinng is very difficult to detect. Quartz inclusions are common here giving some grains sieve-like texture.

The quartz grains are much smaller than the surrounding hornblende and plagioclase grains. The quartz crystals are clear, unfractured, with even to wavy extinction.

Epidote, sphene and apatite occur as minor accessory grains.

NUMBER M-699

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	55	.80 mm	4.30 mm / .03 mm	xeno blastic	biotite apatite			heavy fracturing	
Microcline	30	.70 mm	2.20 mm / .04 mm	xeno blastic	quartz biotite	sericite	tartan	random fracturing	
Biotite	15	.25 mm	1.30 mm / .02 mm	hypidio blastic	opaques				
Epidote	2	.35 mm	.60 mm / .01 mm	xeno blastic	microcline			fracturing prest.	one idioblastic grain
Apatite	<1	.06 mm	.10 mm / .02 mm	idio blastic					accessory

COMMENTS:

M-699

This is another example of a biotite granite gneiss. The relationship between the mineral grains forms a granoblastic fabric. The parallel orientation of biotite gives the rock a schistose character. All of the grains are outlined by impurities making even the quartz and feldspar grains visible with uncrossed nicols.

The quartz grains are elongate in the direction of the schistosty, broken by moderate to heavy fractures. The grain contacts are uneven to embayed with wavy extinction patterns. Inclusions of microcline, biotite and epidote are present with small crystals of apatite.

The microcline grains show tartan twinning and perthite texture. Sericite alteration can be heavy in some grains. Quartz, biotite and epidote are grain inclusions.

Biotite is pleochroic in yellow-brown to a dark red-brown. The grain outlines are not sharp. Opaque minerals, quartz are included in the grains.

Xenoblastic epidote shows faint green pleochroism. In areas it has a granular appearence but it occurs mostly as individual grains.

NUMBER M-700

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	45/50	.80 mm	1.60mm/.03 mm	Xeno blastic	biotite epidote apatite			minor fracturing	contacts even to sutured
Plagioclase/microcline	35/40	.60 mm	2.30 mm/.03 mm	Xeno blastic	quartz biotite	Sericite	albite carlsbad	minor fracturing	
Biotite	10	.60 mm	.70mm/.02 mm	Xeno blastic	opaques	penninite chlorite			
Epidote	5/7	.50 mm	.80 mm/.03 mm	idio and xeno blastic			simple	heavy fractures	
Apatite	<1	.04 mm	.16mm/.02 mm	idio blastic					accessory

COMMENTS:

M-700

The principal consituants of this granoblastic granite-gneiss are quartz, plagioclase, biotite and epidote. The lineated fabric is produced by parallel grains of biotite and quartz grains elongate in the direction of lineation.

The quartz grains are of uniform size, unfractured and display undulose extinction. Grain to grain contacts tend to be embayed. Most grains are free of inclusions, however, minor amounts of apatite, epidote and biote do appear.

The plagioclase displays fine lamalle of albite twinning. Occasionally these twin lamalle are curved and often they do not run the entire length of the grain. Pericline and Carlsbad twins also appear. Not every plagioclase is twinned. Alteration to sericite is common with some grains being rather heavily altered. Grain inclusions consist of apatite, biotite, quartz and epidote. Albite extinction angles of 8° indicate obligoclase composition.

Epidote is limited in its area, occurring only along a fracture that runs through the slide. The highly fractured grains are xenoblastic.

Biotite is pleochroic in light brown to brown. Opaque minerals and penninite alteration are found within the crystals. Although zircon is present in the sample there are no pleochroic halos in the biotite.

NUMBER M-701

NAME hornb-plag amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	60	.70 mm	1.80 mm / .02 mm	idioblastic xenoblastic		biotite (minor)	simple	cleavage {110} two directions	
Plagioclase	30	.50 mm	1.40 mm / .04 mm	xeno blastic	hornblende	sericite	carlsbad albite pericline		An_{20}
Epidote	5	.20 mm	1.00 mm / .01 mm	idio xeno blastic			simple	some fractures	
Apatite	1	.04 mm	.06 mm / .02 mm	idio blastic					
Biotite	2	.50 mm		xeno blastic		penninite			

COMMENTS:

M-701

This granoblastic amphibolite is made of hornblende, plagioclase and minor amounts of epidote.

The hornblende crystals are pleochroic in yellow green to green. This light coloring may be due to the thinness of the slide. The edges of the grains are distinct. There is some alteration to brown biotite. Inclusions of plagioclase and some epidote are common.

Albite twinning is common in all the plagioclase grains although good, sharp, continuous lamallae are not formed. Sericite alteration is heavy in some grains. Inclusions of hornblende, apatite and epidote are present. Andesine compositionis indicated by 15°-16° extinction angle measurements.

Epidote is a minor constituant, equally distributed throughout the slide.

NUMBER M-702

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	50	1.30 mm	4.50 mm/.02 mm	xeno blastic	biotite microcline zircon			fracturing not all grains	contacts embayed sutured
Microcline	40	1.20 mm	4.0 mm/.03 mm	xeno blastic	graphic quartz intergrowth, muscovite biotite	sericite			
Biotite	7	.17 mm	.75 mm/.02 mm	xeno blastic	opaques	chlorite			
Muscovite	3	.05 mm	1.60 mm/.01 mm	xeno blastic					
Zircon	<1	.06 mm	.10 mm/.04 mm	xeno blastic					accessory

COMMENTS:

M-702

This medium grained granite-gneiss has a heteroblastic fabric. The coarser grains of quartz and feldspar are intermixed with smaller grains of quartz, feldspar and biotite.

The larger quartz grains have strongly undulose extiction. Frącturing is not major. Grain to grain contacts are embayed to slightly sutured. These larger grains are mostly free of inclusions with only occasional biotite and zircon grains. The smaller quartz grains have the same general appearence but contain more biotite inclusions.

The microcline occurs in much the same manner as the quartz. The larger grains contain tend to be untwinned or have faint twinning. In the smaller grains perthite texture and tartan twins are more numerous. Alteration to sericite is common to both size grains.

Biotite is pleochroic in olive-brown to deep brown with some penninite alteration. Green chlorite also occurs as an alteration product. The biotite is found in fractures and between the large quartz and microcline crystals.

Zircon is present as an accessory mineral.

NUMBER M-703

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	55	1.00 mm	11.00 mm / .04 mm	xeno blastic	apatite zircon			irregular fractures	contacts uneven embayed sutured
Microcline	35	1.10 mm	2.5 mm / .03 mm	xeno blastic	quartz biotite	sericite	tartan		
Biotite	10	.50 mm	1.90 mm / .02 mm	xeno blastic	opaques zircon	chlorite penninite			
Muscovite	<1	.09 mm	.40 mm / .01 mm	xeno blastic					product of feldspar alteration
Apatite	<1	.05 mm		idio blastic					accessory
Zircon	<1	.06 mm		xeno blastic					accessory

COMMENTS:

M-703

This granite-gneiss is similar to M-702. The two distinct grain sizes present give this rock a heteroblastic fabric.

The larger grains of quartz are moderately fractured and exhibit strong undulose extinction. Grain to grain contacts are embayed to slightly sutured. Most grains are free of inclusions although some apatite, biotite and zircon can be found. The smaller grains of quartz are unfractured and have smoother grain contacts.

Of the larger feldspar grains, most are untwinned, some have tartan twinning. Of the smaller grains the tartan twins of microcline dominate, though not all of the grains are twinned. Graphic inclusions of quartz occur in the smaller grains. Quartz, biotite and apatite are present in all of the feldspars.

The biotite is pleochroic in brown with little color change upon rotation of the stage. Penninite alteration is common to many of the grains. Quartz and opaque minerals are present as inclusions. The grain edges are not well defined. The biotite crystals are found in the smaller grained area of the slide.

NUMBER M-704

NAME Epidotite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Clino zoisite	30	5.00 mm	10.00 mm / .10 mm	xeno blastic	quartz sphene				
Tremolite	20	.40 mm	1.60 mm / .02 mm	xeno blastic	quartz sphene				
Epidote	15/20	1.80 mm	3.50 mm / .09 mm	hypidio blastic	quartz sphene				
Calcite	15			xeno blastic					fills fracture
Hornblende	10	.40 mm	1.60 mm / .02 mm	xeno blastic	quartz sphene				
Quartz	5/10	.19 mm	1.80 mm / .03 mm	xeno blastic	sphene amphiboles carbonate				
Sphene	5/10	.15 mm	.45 mm / .01 mm	hypidio blastic					

COMMENTS:

M-704

M-704 is a medium to coarse grained epidotite without an oriented fabric. The epidote, amphibole and quartz are set in a background of calcite which fills fractures throughout the rock.

The epidote has either a slight green pleochroism of is clear. Under crossed nicols the annomalous blues and yellows of clinozoisite can be seen along with the higher interference colors of epidote. The epidote crystals can be quite coarse however they do not have a solid appearance. Vugs in the grains are filled with quartz, calcite, amphiboles, and accessory minerals. Cleavage is visible, especially in the larger grains.

The amphibole grains vary from those pleochroic in blue-green to clear. This would indicate a range from hornblende to tremolite. Reaction rims are not present but there is some alteration to green chlorite.

Quartz is a minor member in this sample. The grains fill spaces between the other minerals present. These grains are unfractured and have even extinction.

Sphene is found throughout the slide as an accessory mineral.

Calcite is also found throughout the slide filling fractures between grains.

NUMBER M-705

NAME hornb-plag-epid amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	40	.85 mm	2.10 mm / .03 mm	hypidio blastic	quartz zircon epidote plagioclase				
Plagioclase	20 / 25	.75 mm	1.6 mm / —	xeno blastic		sericite alteration almost total	albite carlsbad		
Epidote	15	.80 mm	2.59 mm / .03 mm	idio hypidio blastic					
Quartz	10	.23 mm	5.10 mm / .02 mm	xeno blastic	epidote hornblende calcite				
Calcite	10			xeno blastic					fills fractures
Sphene	3	.08 mm	.37 mm / .02 mm	hypidio blastic					accessory

COMMENTS:

M-705

This rock has three distinct mineral groups with sharp boundaries between each. An amphibolite band has nematoblastic fabric of oriented hornblende, plagioclase and quartz grains. The next layer is made of epidote, hornblende, diopside and extremely altered plagioclase grains. The boundary between these two groups is distinct but non-linear. There is no preferred orientation in this second group. Elongate grains of quartz cut across and into the epidote zone at the top of the slide. These grains intersect the second zone at an acute angle in relationship to the lineation of the amphibolite layer. Large feldspar grains are also present in this area. Both the quartz and feldspar are encircled by calcite filling in fractures.

The hornblende in the amphibolite section is pleochroic in yellow-green to blue-green. Plagioclase is included in these crystals.

The andesine in the amphibolite section has extinction angles of 16°-18°. Albite and pericline twins can be seen in a few grains.

Quartz is not equally distributed throughout the amphibolite section but is confined to a layer within this band.

Grains of epidote, hornblende and diopside in the second zone are all intermixed with poor definition of the

M-705 cont.

grain boundaries.

The epidote is pleochroic in green and occurs in xenoblastic grains and in a vein that cuts through a portion of the slide.

The hornblende in this section is pleochric in green to very blue-green and appears to result from the alteration of the augite.

The diopside has a greenish tint, Parallel cleavage lines are helpful in determining the extinction angle. All diopside grains have a dirty, altered appearance.

The feldspar is highly altered, without any twinning or internal structures visible.

The coarse grained quartz has wavy extinction, fractures and embayed contacts.

The coarse feldspar grains have fine lamalle of albite and pericline twins. Sericite alteration is present but not as heavy as in the other sections of the slide. Albite twin angles of 8°-10° put the feldspar in the oligoclase range.

A single large apatite crystal is present at the quartz and epidote boundary.

NUMBER M-706

NAME Epidotite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Epidote	30	2.50 mm	12.00 mm / —	idio xeno blastic	quartz calcite hornblende			highly fractured	
Quartz	25	2.40 mm	10.00 mm / .07 mm	xeno blastic	calcite diopside				
Calcite	10			xeno blastic					
Hornblende	15	.70 mm	2.00 mm / .05 mm	xeno blastic					
Diopside	20	2.50 mm	4.80 mm / .12 mm	idio xeno blastic		hornblende		parting	

COMMENTS:

M-706

This sample is the same as M-713 which is described later. The differences between the two are the less idioblastic nature of the epidote and the presence of opaque minerals in M-706

NUMBER M-707

NAME hornb-plag amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Plagioclase	45	.50 mm	1.10 mm/—	xeno blastic	epidote hornblende apatite	highly sericitized	albite		
Hornblende	35	.60 mm	1.50 mm/.03 mm	xeno blastic	hornblende			moderate fractures	
Epidote	15	.50 mm	2.20 mm/.01 mm	xeno blastic			simple	fractures present	occurs in veins
Quartz	2	.12 mm	.42 mm/.02 mm	xeno blastic					
Apatite	2	.05 mm	.12 mm/.03 mm	idio blastic					

COMMENTS:

M-707

This sample is an amphibolite with granoblastic fabric. The amphibole, hornblende, shows a parallel orientation of grains. Cutting across the slide at various places are linear bands of epidote.

The plagioclase has sericite alteration which is very heavy in almost every grain. Carlsbad and albite twinning are visible in some grains. The grains, of andesine composition, have 15°-15° extinction angles.

The hornblende is pleochroic in yellow-green to bluish-green. The crystals are of a uniform size. Grain shapes are xenoblastic. Alteration to brown biotite occurs mainly along fractures. Albite and apatite are found as inclusions as well as opaque minerals.

Epidote is found in veins. Grain sizes range from coarse to granular.

Apatite is well distributed throughout the slide and can be quite large.

NUMBER M-708

NAME hornb-plag-qtz amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	40	1.20 mm	2.00 mm / .02 mm	xeno blastic	quartz zircon sphene				
Plagioclase	40	.85 mm	1.6 mm / .01 mm	xeno blastic	hornblende sphene quartz				
Quartz	10	.60 mm	.90 mm / .03 mm	xeno blastic	hornblende sphene apatite				
Epidote	3	.40 mm	.80 mm / .04 mm	xeno blastic					
Sphene	3	.07 mm	.41 mm / .03 mm	idio hypidio blastic					
Calcite	3			xeno blastic					fills fractures
Apatite	1	.06 mm	.23 mm / .03 mm	idio blastic					

COMMENTS:

M-708

This banded amphibolite has granoblastic texture, Layers of hornblende and plagioclase alternate with layers of quartz and feldspar. This banding is linear and may be interpreted as relic sedimentary texture.

In the amphibolite bands, hornblende appears pleochroic in yellow-green to bluish-green. Included within the grains are opaque minerals, apatite, sphene and plagioclase. No reaction rims are present but much of the hornblende has been altered to green chlorite.

The feldspar in the slide has been altered to sericite which hides the internal structure of the grains. In the quartz rich regions, unaltered microcline has tartan twinning and perthie texture. Quartz, hornblende, sphene, apatite and epidote are inclusions.

Epidote is confined to the amphibolite sections occurring in a vein that run parallel with the texture.

The quartz grains have embayed contacts and undulose extinction. Zircon and green chlorite are contained in the quartz grains, and most grains contain microlite inclusions.

Calcite veins fill fractures in the quartz rich regions. Also, a vein of chlorite is in this area.

Sphene and apatite are found only in the amhibolite sections.

NUMBER M-709

NAME hornb-plag amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Plagioclase	50	.80 mm	4.3 mm / .07 mm	xeno blastic	apatite hornblende epidote	total sericite alteration	faint albite twins		
Hornblende	20	1.30 mm	2.00 mm / .07 mm	xeno blastic	apatite feldspar opaques	chlorite			
Epidote	5	.30 mm	.80 mm / .05 mm	xeno blastic	opaques feldspar				
Apatite	10	.30 mm	1.2 mm / .05 mm	idio hypidio blastic					
Calcite	5								fills fractures
Microcline	10	.35 mm	1.20 mm / .03 mm			minor sericite			

COMMENTS: Microcline relatively unaltered

rock may contain brown basaltic hornblende

M-709

This sample is a medium-grained amphibolite consisting of hornblende, plagioclase, epidote and apatite. The rock has no preferred orientation of grains and has a granoblastic fabric.

The hornblende in this sample is pleochroic in yellow-green to blue-green and contains inclusions of plagioclase, apatite, and opaque minerals. The grain boundaries are not sharp but individual grains can be easily identified. Heavy fracturing and parting darken the grains. The hornblende is altering to green chlorite.

Epidote is pleochroic in lime green. It is evenly distributed in the slide though it is not a major component. The epidote occurs as individual grains.

The plagioclase appears to be moderately coarse grained showing faint albite and pericline twinning. Heavy sericite alteration inhibits good viewing of the crystals.

Apatite crystals in the rock are large and plentiful.

NUMBER M-710

NAME Epidotite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Epidote	35	1.00 mm	2.50 mm/.05 mm	Xeno blastic	sphene quartz hornblende				
Quartz	20	.35 mm	1.70 mm/.03 mm	Xeno blastic	apatite epidote				
Plagioclase	20	.60 mm	1.70 mm/—	Xeno blastic	epidote sphene	sericite	albite		
Hornblende	15	.60 mm	1.50 mm/.03 mm	Xeno blastic	sphene apatite epidote				
Sphene	5	.15 mm	.35 mm/.02 mm	Xeno blastic					
Apatite	<1	.13 mm	.20 mm/.02 mm	idio blastic					accessory
Calcite	5			Xeno blastic					fills fractures

COMMENTS:

M-710

This granoblastic rock is made of epidote, quartz and plagiolcase with accessory sphene. A linear pattern is developed in the rock although the grains themselves show no preferred orientation.

The epidote crystals are pleochroic in lime green. Intergrown with the epidote is blue-green hornblende. Sphene, quartz and plagioclase are found as inclusions. Individual grains are not well defined due to faint grain boundaries and the xenoblastic shape of the grains.

The quartz grains have undulose extinction and embayed contacts. Inclusions of sphene and epidote do not appear in every grain. Apaptite crystals are also included in quartz.

Alteration to sericite is present in all of the plagioclase present. Albite twins are visible but poorly defined. Plagioclase is not equally distributed through the slide but is found where there is a concentration of hornblende.

Sphene is is present as an accessory mineral and calcite is found filling fractures.

NUMBER M-711

NAME hornb-plag-epid amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Epidote Zoisite	40	.50 mm	1.20 mm/.02 mm	xeno blastic	sphene calcite				berlin blue
Hornblende	35	.75 mm	2.50 mm/.04 mm	xeno blastic	sphene epidote plagioclase	chlorite			
Plagioclase	10/15	1.20 mm	—/—	xeno blastic	sphene hornblende	total sericite alteration	faint albite twins		size can't be determined
Sphene	10	.08 mm	1.10 mm/.03 mm	hypidio blastic	opaques				
Calcite	3			xeno blastic					fills fractures
Apatite	<1	.05 mm	.18 mm/.03 mm	idio blastic					accessory
Quartz	2	.10 mm	.60 mm/.02 mm	xeno blastic	sphene				minor

COMMENTS:

M-711

This is another example of intergrown crystals of hornblende and epidote. A granoblastic fabric is best seen macroscopically and no foliation is formed in the rock.

The anomalous blues and yellows of clinozoisite account for over seventy-five per cent of the epidote. Higher interference colors and green pleochroism are shown by the other epidote in the slide.

Hornblende is faintly pleochroic in blue-green to green and has alterations to green chlorite. Some of the amphibloe present is not pleochroic and may be considered as tremolite. In one corner of the slide, hornblende is found with plagioclase forming amphibolite.

Coarse grains of sphene are distributed throughout the sample.

Intergranular calcite is restricted to the epidote rich areas of the slide.

NUMBER A-712

NAME hornb-plag epid amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Epidote	35	.60 mm	6.20 mm/.03 mm	xeno blastic	sphene calcite				
Hornblende	25	1.70 mm	2.50 mm/.05 mm	hypidio xeno blastic	sphene plagioclase	chlorite			
Plagioclase	15	1.50 mm	2.10 mm/.07 mm	xeno blastic	sphene hornblende	sericite	albite carlsbad		
Tremolite	15	.65 mm	4.40 mm/.04 mm	xeno blastic	sphene hornblende				
Sphene	10	.13 mm	.65 mm/.03 mm	hypidio blastic					
Calcite				xeno blastic					fills fracture
Apatite	<1			idio blastic					accessory

COMMENTS:

M-712

This is another example of a rock with two distinct characters. One third of the sample is a granoblastic amphibolite with no preferred orientation of grains. Hornblende and plagioclase are the dominant minerals with epidote, sphene and apatite also present. Intergrown epidote and hornblende make up the other two-thirds of the sample. Plagioclase, sphene, and calcite are also found here.

Hornblende is pleochroic in yellow-green to blue green. Where the hornblende is found with epidote the pleochroism is faint which perhaps indicates a switch towards tremolite. In the amphibolite section, individual grain boundaries are distinct.

The plagioclase throughout the slide has been heavily altered to sericite. Albite twins are only occassionally visible and are not well developed. Sphene, hornblende and apatite are present as inclusions.

The size and shape of the epidote crystals are difficult to determine. Green pleochroism is shown under uncrossed nicols. Under crossed nicols, the berlin blue of clinozoisite is displayed by a quarter of the epidote.

Sphene is much more abundant in the epidote portion of the slide than in the amphibolite area.

NUMBER M-713

NAME Epidotite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	35	3.00 mm	10.00 mm / .05 mm	xeno blastic	calcite diopside			minor fractures	sutured edges
Epidote	30	4.00 mm	14.20 mm / .05 mm	hypidio blastic	quartz calcite			highly fractured	sharp crystal edges
Diopside	20	2.00 mm	4.50 mm / .03 mm	xeno blastic	quartz calcite	hornblende		highly fractured	
Hornblende	10	1.50 mm	2.70 mm / .04 mm	xeno blastic	quartz epidote	chlorite			fills fractures
Calcite	5/10								
Spinel	2	.65 mm	1.50 mm / .04 mm	idio blastic	quartz			highly fractured	

COMMENTS:

M-713

Coarse grains of quartz, epidote and diopside dominate this epidotite. Sharp, distinct crystals facies of epidote are visible along contacts with quartz and calcite which would indicate that the later were introducted after the formation of the epidote. Diopside crystals also have idioblastic shape when the grains boarder quartz on calcite regions. Epidote to epidote grain contacts do not show the same cystal development.

The epidote crystals are pleochroic in green and are highly fractured. Some cleavage lines can be seen but are not well developed. At one edge of the slide smaller epidote grains are intermixed with hornblende and diopside. Here, the individual grain boundaries are not easily decerned. Calcite and quartz fill fractures in the grains. Also present is a brown, isotropic mineral that appears to be spinel.

The diopside crystals here are heavily fractured, with some showing parallel parting. Alteration to hornblende is present in most of the grains.

The quartz grains are coarse with undulose extinction. No inclusions are present. Fractures and intergranular spaces are filled by calcite.

NUMBER M-714

NAME hornb-plag-epid amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Hornblende	25	1.00 mm	2.40 mm / .03 mm	xeno blastic	apatite sphene feldspar				
Plagioclase / microcline	25	.65 mm	1.80 mm / .04 mm	xeno blastic	apatite hornblende sphene epidote	sericite (heavy alter.)	albite		
Epidote	20	.25 mm	9.30 mm / .03 mm	xeno blastic	sphene tremolite				
Tremolite	5	1.10 mm	3.80 mm / .08 mm	xeno blastic	calcite hornblende zircon				
Sphene	10	.14 mm	1.40 mm / .03 mm	hypidio blastic	epidote				
Apatite	2	.06 mm	.19 mm / .23 mm	idio blastic					
Calcite	3			xeno blastic					fills fract.

COMMENTS:

M-714

This sapmle has two distinct mineral associations. The conact between the two is a well defined, highly visible line. Seventy-five per cent of the rock is a medium-grained granoblastic amphibolte, consisting of hornblende and plagioclase. The remainder is rich in epidote with hornblende, sphene and calcite.

The hornblende is pleochroic in yellow-green to bluish-green. In the amphibolite section, the grain boundaries are easily disernable. No reaction rims are present though there is alteration to brown biotite. Sphene and plagioclase are also found within the grains.

By examining the extinction patterns of the feldspar grains an idea of the size of the crystals can be formed. However, because of the extreme sericite alteration, individual grain boundaries and internal structures are completely obscured. Only faint albite twin lines can be seen but are not useful in determining composition. Also present are untwinned feldspar grains, some of which Have perthite texture. These potassium rich grains are not altered to sericite even though they boarder plagioclase grains which are. One third of the feldspars are unaltered.

The epidote-hornblende region compares in many ways with M-716. Noticeable differences are the absence of quartz and clinozoisite. Grain boundaries between the

epidote and hornblende are very indistinct, making individual measurements difficult.

Sphene is liberally distributed through this area. Calcite found here fills fractures and appears to be secondary in origin.

NUMBER M-715

NAME Quartzo-Feldspathic schist

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Microcline	50	.65 mm	1.70 mm / .06 mm	xeno blastic	apatite biotite quartz	sericite	tartan		
Quartz	30	.50 mm	1.40 mm / .02 mm	xeno blastic	apatite biotite			minor fracturing	uneven embayed sutured
Biotite	20	.80 mm	2.00 mm / .02 mm	xeno blastic	opaques zircon	penninite chlorite			
Apatite	1	.10 mm	.45 mm / .01 mm	idio blastic					
Zircon	<1								accessory

COMMENTS:

M-715

This granite-gneiss contains quartz, microcline and biotite. Orientation is best seen in the biotite grains which run in parallel bands.

Although no porphyroblasts are present, there is a great range in the size of the quartz grains. Patches of small grains have a chert-like appearance. Many grains have sutured contacts. Other grains have uneven to embayed contacts. Extinction patterns are wavy to strongly undulose. Biotite and apatite are found as inclusions.

Biotite is pleochroic in brown to light brown with alteration to penninite. Inclusions of opaque minerals, quartz and large apatite crystals are present. The grain outlines are not distinct.

Tartan twins in the microcline and perthite texture mark the feldspar present. Inclusions include apatite, quartz and biotite. Many of the grains have altered to sericite.

Apatite crystals are large and have idioblastic shape.

NUMBER M-716

NAME hornb-plag-epid-qtz amphibolite

FACIES amphibolite facies

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Epidote	35	.13 mm	6.5 mm / .02 mm	xeno blastic	sphene hornblende quartz				
Hornblende	20	1.50 mm	4.2 mm / .06 mm	xeno blastic	sphene epidote quartz	chlorite			
Quartz	15	1.50 mm	4.00 mm / .02 mm	xeno blastic	calcite in fractures				
Plagioclase	10	.80 mm	2.20 mm / .05 mm	xeno blastic	epidote	sericite	albite		
Sphene	5/10	.20 mm	.50 mm / .05 mm	idio hypidio blastic					
Apatite	5		2.5 mm / .03 mm	idio xeno blastic					
Calcite	5								fills fractures

COMMENTS:

M-716

This medium-grained epidotite contains epidote, quartz, hornblende, plagioclase and sphene. All of the grains are randomly arranged in a granoblastic fabric. Individual grain boundaries for epidote, hornblende and plagioclase are very indistinct.

The epidote has some grains pleochroic in lime green. Fracturing of the grains is moderate to heavy. Cleavage patterns are not well developed. Some pleochroic grains have Berlin blue interference colors indicating clinozoisite is also present. The ratio of epidote to clinozoisite is about 2:1.

Intergrown with the epidote is hornblende. These grains have green to yellow-green pleochroism. Contained as inclusions in the grains are sphene and opaque minerals.

Quartz, plagioclase and calcite are not equally distributed throughout the slide. Patches of these minerals do contain some epidote inclusions but appear to be secondary minerals. The quartz grains have even extinction patterns but the grain contacts are obscure.

The plagioclase has faint albite twinning showing through sericite alteration. Calcite can be found the epidote rich regions, filling fractures and in the quartz rich region encircling both quartz and fedlspar.

A large xenoblastic grain of apatite also has its fractures filled in by calcite.

NUMBER M-717

NAME Microcline Pegmatite

FACIES

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Microcline	93			xeno blastic		sericite	tartan albite	heavy fracturing	perthite
Albite	5	1.50 mm		xeno blastic					
Opaques	2								

COMMENTS: grains to large to measure microscopically.

M-717

This is an extremely coarse grained feldspar rock which is unique among the samples identified here. Microcline is the dominant mineral in the slide. Contained in these coarse grains are smaller feldspar grains with albite twins made of fine twin lamallae often have kinks in these bands. The albite twins have 10°-12° extinction angles for an An_{10} composition. The larger grains have tartan twinning and perthite texture.

Opaque minerals are also contained in this sample.

Because of the composition and coarse grain size this rock might be of pegmatite origin.

NUMBER M-718

NAME Feldspathic-Quartzite

FACIES

LOCALITY Breckenridge, Colorado

MINERAL	%	AVE. SIZE	MAX/ MIN	SHAPE	INCLUSIONS	ALTERATIONS	TWINNING	FRACTURE	OTHER
Quartz	70	.40 mm	4.70 mm / .04 mm	xeno blastic				minor fracturing	contacts uneven to sutured
Epidote	20	.04 mm	.33 mm / .01 mm	xeno blastic					granular, along fractures
Plagioclase	10	.80 mm	3.29 mm / .15 mm	xeno blastic		some highly sericitized	albite		
Calcite	<1								in fractures

COMMENTS:

M-718

This sample is a quartzite containing small amounts of feldspar. Epidote in the rock is found exclusively along fractures and appears to have been added as a secondary mineral, after the formation of the quartzite.

Quartz grains dominate the slide. The size of the grains range from very coarse to small, chert-like masses. Common to all quartz grains are sutured grain contacts and undulose extinctions. Neither fractures nor inclusions are part of the grains.

The plagioclase has albite and pericline twins. Some of the albite twins have kinks in their lamalle due to deformation. Measured extinction angles show that the plagioclase has the composition of albite. Seridite alteration affects most of the grains but this alteration is not severe.

The epidote has a granular, sugary appearence. It is found along fractures and not as inclusions in the Quartz grains.